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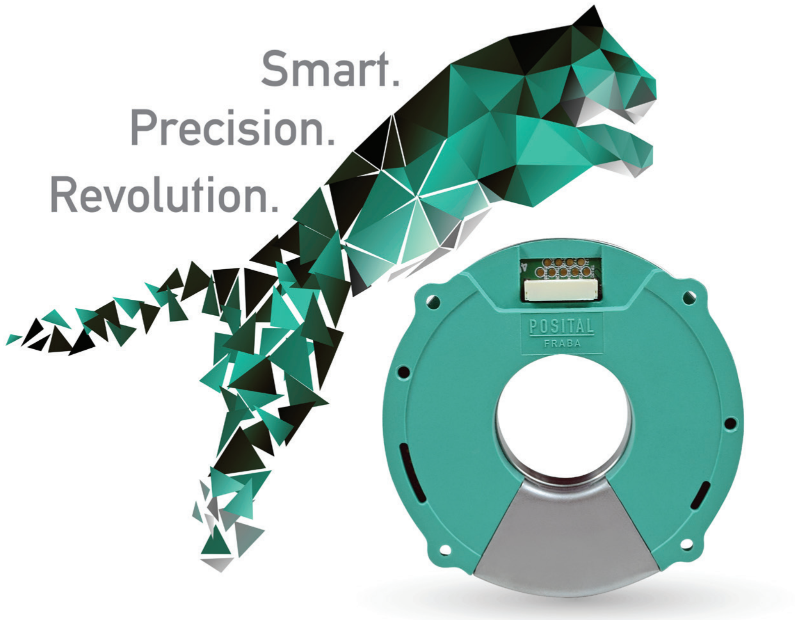
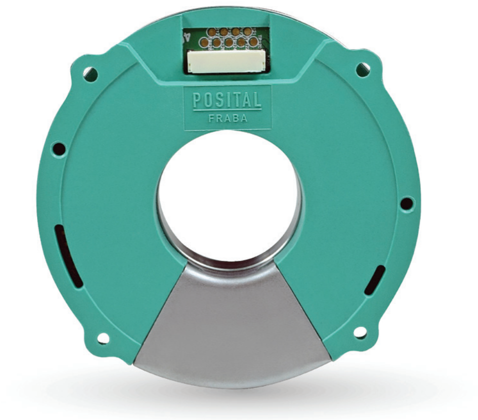
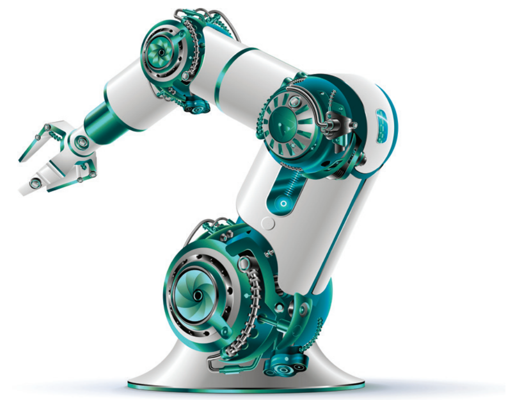


POSITAL Hollow Shaft Kit Encoders for Position Control Applications

POSITAL's new hollow shaft kit encoders are designed for installations where it is useful to have a rotary position measuring element (encoder) fit around a machine's shaft or axle. With their generous center openings (30 or 50 mm) and available multiturn measurement range, these are an excellent solution for many installations, including servomotors, feedback-controlled stepper motors and robot joints. These devices are based on an advanced capacitive measurement technology that combines accuracy, reasonable installation tolerances and rugged reliability. They also feature self-powered rotation counters that eliminate the need for backup batteries and significantly reduce maintenance costs.





A New Form Factor

POSITAL is a leader in the development of rotary encoders position and other motion sensors for industrial applications. These devices provide a digital measure of angular position (absolute encoders) or rate of rotation (incremental encoders). Most encoders in the company's catalogue have position sensing elements that are located at the center of the device. While this is satisfactory for many applications, there are situations where designers would prefer to use measurement devices that fit around a central shaft, axle or structural element.

For Example:

- For servomotors, stepper motors or drives, it can be convenient to measure shaft rotation with a position sensor that fits around the drive shaft.
- Robot joints can be designed with a central hinge pin, or with electrical cables and air hoses routed through the center of the joint. Devices that measure joint angle while fitting around these structural elements can be used to create more compact joints.

POSITAL's new series of ring-shaped hollow shaft kit encoders are designed to meet these requirements and give designers more flexibility when configuring motion control systems. With these devices, designers of servomotors or feedback-controlled stepper motors can lay out their equipment with position sensors at either end of the motor's shaft.

Multiturn Measurement Range – Without Gears or Batteries

POSITAL's new hollow shaft kit encoders are available with multiturn measurement ranges. This means that these devices can keep track of the number of complete shaft revolutions, as well as reporting the precise angular position of the rotor within each rotation. Multiturn measurements are useful for monitoring the position of mechanical components when, for example, a motor drives a screw shaft, cable drum or reduction gear system.

For a reliable multiturn encoder system, it is essential that the rotation counter be able to keep an accurate count of the number of complete revolutions that the device has experienced, even if these occur when instrument power is not available. (If a rotation counter fails to record every mechanical revolution, positional accuracy can be lost. In this case, it is usually necessary to "re-home" the system by returning the entire machine to a known reference state and re-initiating the rotation count.) To ensure accurate position counts under all operating conditions, some encoder manufacturers include a backup battery to keep the rotation counter energized when instrument power is unavailable.

The rotation counters for POSITAL multiturn absolute encoders are self-powered. With each shaft rotation, pulses of electricity created by a Wiegand wire system provides the energy needed

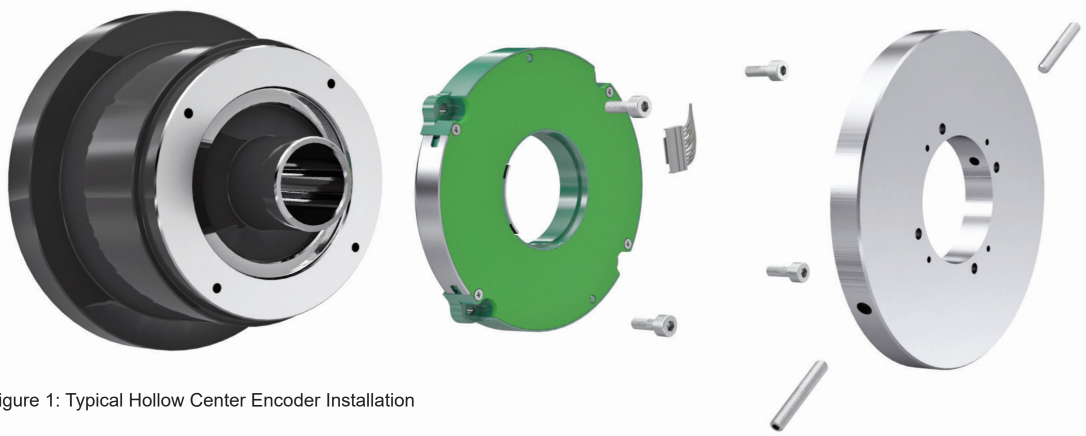


Figure 1: Typical Hollow Center Encoder Installation

to activate the rotation counter. This ensures that the rotation count is always accurate, with or without the availability of an external instrument power source. No backup batteries are required! Eliminating the need for batteries reduces downtime, lowers maintenance costs and avoids the need to dispose of spent batteries (which can contain hazardous materials).

The multiturn counter has a 43-bit memory, for a measurement range of almost nine trillion revolutions.

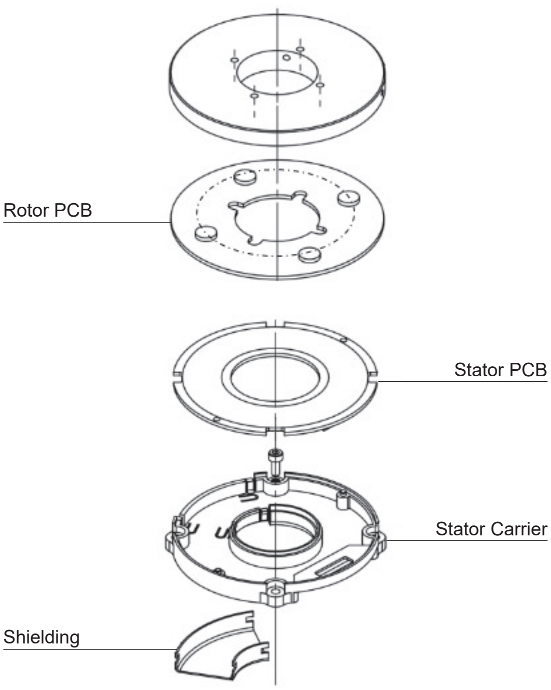


Figure 2: Hollow Center Encoder Components

The complete multiturn capacitive encoder system, including the stator components and electronics, the rotor disk, the Wiegand energy harvesting components and an exterior shell (that contributes mechanical protection and electrical shielding) are contained in an 18 mm thick package. (Thinner packaging is possible with singleturn models that do not require rotation counting circuits and the accompanying Wiegand power source.)

Capacitive Rotation Measurement

The new hollow shaft encoders have two main components, both shaped as open-center disks. A **Stator unit** contains control and signal processing electronics and communications interfaces. The **Rotor unit** is designed to be clamped to the rotating part of the machinery (such as a drive shaft), immediately adjacent to the stator.

Both units have specially designed arrays of conductive surface elements on their faces. These elements act as plates in a system of interconnected capacitors.

A simplified representation of the capacitive plates on the face of stator is shown in *Figure 3a*. In this figure, the capacitive surfaces of the stator are organized into three concentric bands. The outer and inner bands of conductive material run around the full circumference of the disk, while the middle band is divided into an array of separated trapezoidal conductive patches.

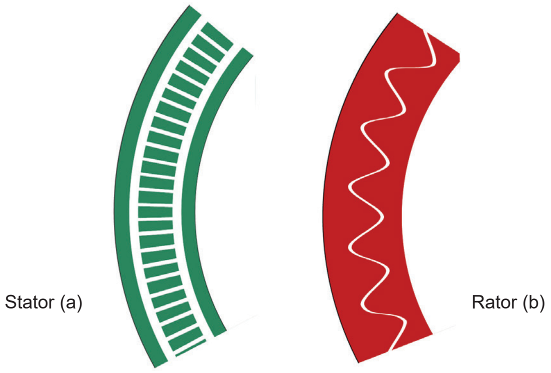


Figure 3: Capacitive Plate Layouts

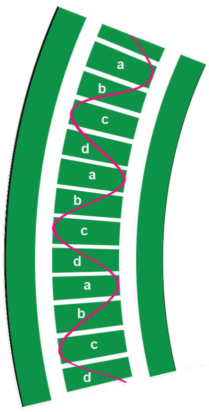


Figure 4

The conductive surface on the rotor has two zones of conductive material, separated by a sine wave shaped gap *(Figure 3b)*.

When the rotor profile is superimposed on the stator, *(Figure 4)* we can see that in some places, the outer conductive zone of the rotor overlaps the outer ring and the middle band of the stator. In other places, inner zone on the rotor overlaps patches on the middle band and the inner conductive ring. Where the conductive surface on the rotor overlaps two bands on the stator, it causes capacitive coupling between these regions.

As the rotor turns, the pattern of capacitive coupling between individual trapezoidal patches in the middle band and the other two bands will change. Medium-frequency electrical signals generated by exciter circuits in the stator are modulated as they pass through this capacitor system, resulting in changes to the phase angle of the output. Special ASIC processors capture and decode these signal variations to determine the rotor's angular position to a high level of precision.

360° Capacitance Measurement

The overlap pattern repeats itself at regular intervals around the circumference of the device. Regardless of the position of the rotor, all stator segments labelled "a" will experience the same degree of overlap from the rotor zones and the same level of capacitive coupling with the inner or outer rings. The same applies to the segments labeled "b", "c" and "d". The encoder design makes use of this repetitive pattern by connecting all "a" segments in parallel, all "b" segments in parallel, and so on, creating four groups of interleaved capacitor systems. Each group is distributed around the full circumference of the disk.

Collecting individual capacitor elements into groups has two important results. First, connecting the small capacitor plates in parallel increases the total capacitance of the system. Second, this 'holistic' approach averages capacitances around the circumference of the device. This cancels out local variations in capacitor strength due to, for example, minor misalignments between the rotor and the stator.

In practice, there are two sets of capacitive bands on the stator and rotor, with different circumferential frequencies. By combining readings from these, the signal processing system can determine the angular displacement of the rotor unambiguously over a full 360°.

Communications Interfaces

The communications interfaces for these products are based on the non-proprietary SSI and BiSS C standards. Unlike most proprietary, vendor-specific interfaces, these open-source standards are available to manufacturers without licensing fees.

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Summary

There are several advantages to the capacitive measurement system used in the POSITAL hollow shaft encoders:

- The hollow center configuration provides designers with extra flexibility when laying out machinery
- Accuracy is very high, with a 19-bit resolution (one part in 524 288).
- Capacitance measurements are taken around the full circumference of the rotor/stator disks. This "holistic" approach means that the system is relatively tolerant of minor alignment errors between the stator and rotor. As a result, these encoders can be installed in servomotor housings or other machines under reasonably clean factory conditions. (By contrast, optical encoders require very precise internal alignment and are typically assembled under laboratory-like conditions.)
- Capacitive measurement systems are relatively tolerant of dust and moisture, both during assembly and in operation.
- Capacitive measurement systems are immune to magnetic fields, including the strong fields from motor brakes. They can, however, be sensitive to strong electrical fields, so that shielding is generally recommended.

Preliminary Technical Specifications

For the initial release of the POSITAL hollow shaft encoders, two sizes will be offered:

- 30 mm central opening diameter,
  80 mm outer diameter, 18 mm thickness
- 50 mm central opening diameter,
  100mm outer diameter, 18 mm thickness

(The basic architecture of the hollow shaft design can easily be adapted to different diameters and more sizes will be offered, depending on industry demand.)

Accuracy:

- +/- 0.02° for 30 mm models,
- +/- 0.02° for the 50 mm version.

Operating temperature range:

- -40 °C to 105 °C

Operating relative humidity:

- up to 90% (non-condensing)

Speed range:

- 0 – 6000 RPM

Multiturn measurement range:

- up to 43 bits (almost 9 trillion revolutions)